Active Galactic Nuclei: from Central Engine to Host Galaxy
ASP Conference Series, Vol. xxx, 2003
S. Collin, F. Combes, and I. Shlosman

Results from a Complete *Chandra* Survey of Radio Jets

D.A. Schwartz (Harvard-Smithsonian Center for Astrophysics),
H.L. Marshall, B.P. Miller (Massachusetts Institute of Technology),
D.M. Worrall, M. Birkinshaw (University of Bristol), J.E.J. Lovell,
D.L. Jauncey (CSIRO), E.S. Perlman (U MD, Baltimore County),
D.W. Murphy, R.A. Preston (Jet Propulsion Laboratory)

1. Summary

We report preliminary results from the first targets observed as part of a program to image the X-ray jets in a complete sample of extragalactic radio jets. We have acquired Australian Telescope Compact Array and Very Large Array data with resolution 1″ , matching the *Chandra* resolution. We tailored our source selection criteria to generate a list of objects that have continuous jets, or associated bright knots, with emission extended over scales > 2″ . We selected targets from two samples: List A from a VLA sample ($\delta > 0°$) of flat spectrum quasars with core fluxes $S_{5\,\mathrm{GHz}} > 1$ Jy (Murphy et al. 1993) and List B from an ATCA survey of flat spectrum Parkes quasars ($\delta < -20°$) (Lovell 1997), with core flux $S_{2.7\,\mathrm{GHz}} \geq 0.34$ Jy. In all, 57 sources comprise the sample, including seven which were observed as parts of other programs and are not included in this poster. In Cycle 3, we were awarded 5 ksec apiece for 20 of the objects, and we report on 16 for which data have been obtained to date, as shown in Table 1.

Table 1. *Chandra* X-ray Data for the 16 Jets

PKS Name	redshift	Time(ks)	Jet Counts	Jet Flux[a]	Jet Predict[b]	Jet Size[c]	L^d_{jet}	AGN L^d_{core}	List A/B
0208-512	0.999	5.014	41	8.0	4.1	41	1.6	63	B
0229+131	2.059	5.410	≤15	≤2.7	3.2	80?	≤2.6	110	B
0413-210	0.808	4.862	25	5.1	11.4	29	0.65	8.8	A
0745+241	0.410	5.019	<15	<2.9	2.9		<0.09	5.0	A
0858-771	0.49	4.962	<15	<3.0	3.9		<0.13	5.9	B
0903-573	0.695	4.934	18	3.6	18.8	30	0.33	13	A
0920-397	0.591	4.466	34	7.5	10.1	77	0.48	7.4	A
1030-357	1.455	5.029	46	9.0	4.0	137	4.1	35	B
1046-409	0.62	4.330	34	7.7	13.5	32	0.55	16	A
1145-676		4.621	≤20	≤4.4	4.5				B
1202-262	0.789	5.074	115	22	11	51	2.7	18	A
1258-321	0.01704	5.426	<25	<4.5	9.6		<0.0002	0.00056	A
1424-418	1.522	4.475	<15	<3.3	3.2		<1.7	110	B
1655+077	0.621	4.825	<15	<3.1	3.2		<0.22	12	B
1655-776	0.0944	4.917	<15	<3.0	3.2		<0.004	0.050	A
1828+487	0.692	5.329	65	12.0	115	48[e]	1.1	47	A

[a]Measured Flux density at 1 keV, nJy [b]Scaled from PKS 0637-753 at 1 keV, nJy [c]X-ray size projected on sky, kpc, using H_0=65, Ω_0=0.3, and Ω_Λ=0.7 [d]Rest frame 2 –10 keV luminosity in units of 10^{44}ergs s^{-1} [e]Extended X-ray emission, not specifically from radio jet

We detect the jet in X-rays for seven of these, while for PKS 0229, PKS 1145, and PKS 1828 there are excess X-ray counts outside the quasar core, but not clearly associated with the jet. These 10 targets are shown in Figure 1.

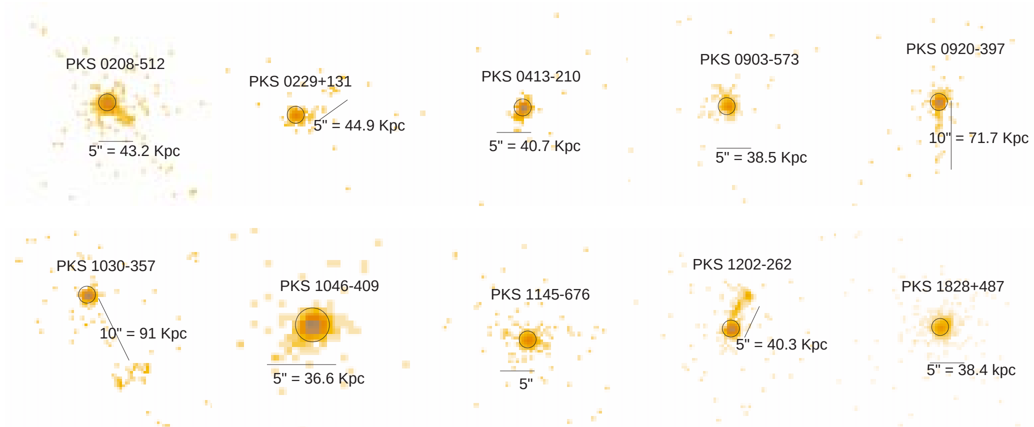

Figure 1. *Chandra* detection of jets and possible extended emission in our complete survey. The fields are all 31.″2 x 29.″5. The X-ray data are selected between 0.5 and 7 keV and binned in 0.″492 pixels. Typical background is 0.002 counts per pixel. The circles are 1.″23 radius about the X-ray centroids, which enclose about 95% of the flux at 1.5 keV.

Several sources, e.g., PKS 0208-512, PKS 1030-357 and PKS 1202-262, show strong correlation with the initial radio jet, but with the X-ray emission declining steeply where the radio jet bends through a large angle. This is similar to the behavior in PKS 0637-752 (Schwartz et al. 2000). The radio to X-ray spectral energy distribution (SED) in the case of PKS 0208-512 proves that the emission is not a simple synchrotron spectrum, due to the low upper limit on the jet optical flux from our Magellan observations (Miller 2002). As in the case of PKS 0637-752, we find that relativistic beaming is necessary to explain the X-ray emission by inverse Compton scattering on the Cosmic Microwave Background, if one assumes the radiating electrons are in near equipartition with the magnetic field in the jet rest frame (Tavecchio et al., 2000; Celotti et al., 2001).

Acknowledgments. This work was supported in part by NASA contract NAS8-39073 to the *Chandra* X-ray Center, NASA grant GO2-3151C to SAO, and SAO SV1-61010 to MIT. E.S.P. acknowledges support from NASA LTSA grant NAG5-9997. This research used the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration, and the NASA Astrophysics Data System Bibliographic Services.

References

Celotti, A., Ghisellini, G., & Chiaberge, M. 2001, MNRAS, 321, L1

Lovell, J.E.J. 1997, Ph.D. Thesis, U. of Tasmania

Miller, B.P. 2002, undergraduate thesis, M.I.T.

Murphy, D.W., Browne, I.W.A., & Perley, R.A. 1993, MNRAS, 264, 298

Schwartz, D. A. et al. 2000, ApJ(Letters), 540, L69

Tavecchio, F., Maraschi, L., Sambruna, R. M., & Urry, C. M. 2000, ApJ(Letters), 544, L23